

Blue Light Special at the DUV-FEL

February 13, 2002 - A specially intense blue light shone for the first time at BNL's Deep Ultra-Violet Free Electron Laser (DUV-FEL). On hand to see this 400-nanometer (billionths of a meter) wavelength light were NSLS scientists Adnan Doyuran, Bill Graves, Henrik Loos, Timur Shaftan, Brian Sheehy, and Li-Hua Yu, with technical specialist Phil Marino. It was a satisfying and visible reward for the hard work of many.

"Achieving this 400-nanometer-wavelength light is an important milestone in the development of the DUV-FEL," says Erik Johnson, the NSLS's DUV-FEL Project Manager. "It paves the way to producing even shorter and more intense 100-nanometer-wavelength laser light."

Visible light's wavelength ranges from 400 to 700 nanometers (nm). When it produces the more energetic 100 nm light, the DUV-FEL will become an important tool for studying chemical reactions.

The commissioning experiment, led by Yu, achieved the visible 400-nm light by Self Amplified Spontaneous Emission (SASE).

The experiment demonstrated that the components of the machine work successfully and have been appropriately tuned. The scientists also found that the light intensity was about 600 times higher than anticipated.

"We were pleasantly surprised by how intense the output light was," says Johnson. At least two factors contributed to this high output and its comparatively rapid attainment, he explains: The high quality of the beam generated by the linear accelerator, and the beam alignment,

which allows rapid and precise correction of the beam trajectory.

"However, light produced by the SASE process is just the starting point for the DUV-FEL program," Johnson says.

The project has its roots in earlier work. In 1999, in what was an important milestone for the field, the High Gain Harmonic Generation (HGHH) process in an FEL was tested for the first time by a team of scientists led by Yu.

This experiment at BNL's Accelerator Test Facility used a 10 micrometer-wavelength infrared laser to provide a coherent starting signal for the lasing process. Some of the same scientists involved in the successful HGHH experiment are now planning to extend that work to wavelengths down to 100 nanometers or fewer at the DUV-FEL.

BNL's DUV-FEL will complement the

NSLS in many ways. The DUV-FEL's pulses of light are up to 1,000 times shorter than those produced at the NSLS, enabling the study of time dynamics of molecules and chemical reactions. DUV-FEL light is also coherent, meaning that the particles of light, or photons, move like soldiers following marching orders, in contrast to incoherent light, in which the photons follow their own pace.

The FEL's coherent light will have a peak intensity more than a billion times higher than that of the NSLS.

"The high power and short timescale of FEL light is expected to open entirely new fields of research in much the same way that the NSLS rings did 20 years ago," says NSLS physicist William Graves, who led the electron beam development effort at the DUV-FEL. "The NSLS will continue to be invaluable to a broad user community, while the FEL will provide en-



While many people were involved in the development and installation of the DUV-FEL machine, a smaller core of individuals carried out the commissioning and initial SASE experiment. Among them: (from left) Richard Heese, Jim Rose, Phil Marino, Timur Shaftan, Li-Hua Yu, (seated) Boyzie Singh, William Graves, Adnan Doyuran, Henrik Loos, and Brian Sheehy. (Not in photo, Joe Greco, Erik Johnson.)

hanced capabilities for some specialized experiments."

The DUV-FEL is one of just a handful of FEL's in the world designed to operate in the ultraviolet, and it is the only facility designed to generate light through the HGHG process.

"It is also an important resource for the FEL research community right now," Graves says, "because most of the other similar FEL programs are shut down for upgrades or are under construction. For a period of about a year, we are the only game in town for doing this kind of work, which will increase our collaboration with scientists from DESY [German Synchrotron Laboratory] and SLAC [Stanford Linear Accelerator Center]."

According to Johnson, the prospects for the facility are bright. "Production of light at wavelengths below 400 nm is planned in the coming year, experimental use of the laser for chemical physics experiments should begin, and it will continue to provide a platform for exploring upgrade paths for the NSLS scientific program.

-Patrice Pages

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Many of the National Synchrotron Light Source's Deep Ultra-Violet Free Electron Laser team are gathered in the Source Development Laboratory, celebrating the successful effort to achieve a 400-nanometer wavelength beam of light.

Learn About the SASE and HGHG Processes

BNL's Deep Ultra-Violet Free Electron Laser uses fast-moving electrons traveling at close to the speed of light. They are produced in a photo-injector and brought to their high energy by a linear accelerator. They then pass through an undulating magnetic field in a "wiggler" device that forces them to wiggle, and thus to emit light.

SASE

In the Self Amplified Spontaneous Emission (SASE) process, the FEL's output light gets its start from "noise," or random signals, that naturally happen in the wiggler.

HGHG

In the High Gain Harmonic Generation (HGHG) process, the FEL's output light starts from the fast-moving electrons interacting with a laser

called the "seeding" laser. The conditions are set so that the output light has a frequency that is a harmonic, or a multiple, of the frequency of the input laser light.

Similarly to the way one can strike a key on a piano and set the strings of higher octaves in motion, the HGHG process shifts the wavelength of the seeding laser to a higher frequency, generating a wavelength for the output light, the HGHG light, that is beyond the range of the original laser.

In addition, the coherence, or orderliness, of the seeding laser is imparted to the output DUV-FEL light, providing a light beam that is significantly more coherent than light produced from SASE sources.

